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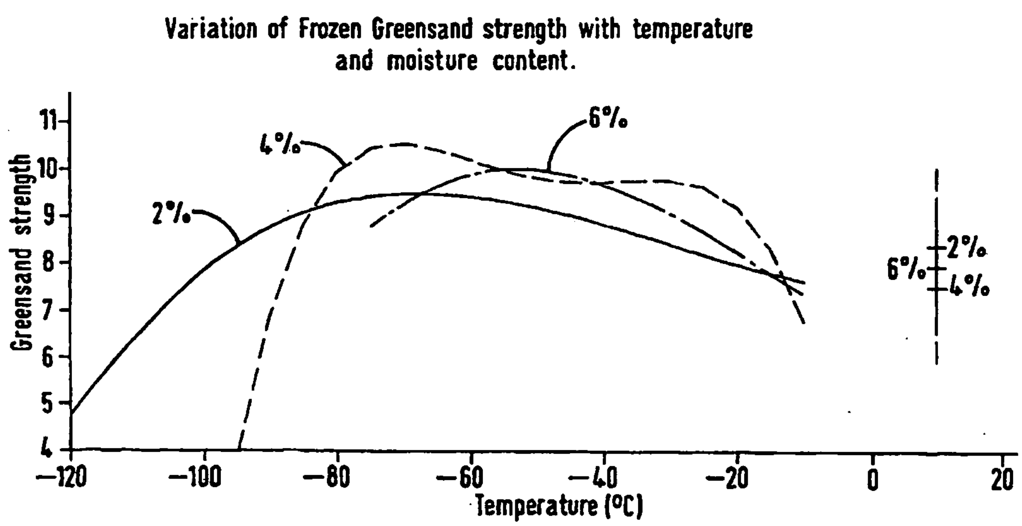
(54) Title: METHOD FOR FORMING A MOULD FOR USE IN CASTING AND MOULD FORMED BY SAID METHOD



(57) Abstract

A method of forming a mould from moist particles of a material comprising sand and from 1 to 15 % (by weight) clay, for example greensand, characterised in that said moist particles are substantially individually cooled to a temperature in the range of from -20 °C to -110 °C and are subsequently compressed against one another to form a mould.

METHOD FOR FORMING A MOULD FOR USE IN CASTING AND MOULD FORMED BY SAID METHOD

This invention relates to a method for forming a mould for use in casting, and to a mould formed by said method.

Traditionally, metal is cast in moulds which are formed by compressing moist particles of a material comprising sand and clay and generally referred to as "greensand" against one another. Each mould is formed by placing a box over a pattern. The box is then filled with the moist particles which are rammed against the pattern. Finally, the box and sand are separated from the pattern. The sand now has an impression of the pattern in it. Depending on the complexity of the casting several moulds may be clamped together with or without core pieces and then filled with molten metal. After the molten metal solidifies the casting is removed from the mould(s) and the greensand recovered for re-use.

The main disadvantage with this procedure is that fine details in a pattern cannot be reproduced reliably. This is largely due to the lack of adhesion between the particles of moist greensand which results in degredation of the impression during handling.

In order to help overcome this problem it has been proposed to very highly compress the moist greensand against the pattern. However, as a casting cools it contracts and if the greensand is too highly compressed parts of the casting can crack as it contracts against the highly compressed greensand. This phenomena is often referred to as "tearing".

In order to overcome this problem the traditional greensand has been replaced by a mixture of sand and resin. (It should be noted that no clay is present). Whilst this technique enables patterns with fine details

to be reproduced and reduces the likelihood of cracking as the casting cools it creates further problems. In particular, unpleasant volatile organic compounds are released as the molten metal is poured. In addition, after use, the resin impregnated mass must either be transported to a land fill site or the sand recovered by burning the resin at high temperatures which generates fumes which contain large quantities of unpleasant volatile organic compounds.

UK-A-1 537 471 and UK-A-1 537 743 describe a method of forming a mould in which an impression is formed in moist greensand. The pattern is then removed and the mould frozen, typically in a tunnel freezer cooled by liquid nitrogen. Molten metal is then poured into the mould as described above. The freezing is generally a relatively time consuming process as the cold front only travels slowly through the mould.

In general, castings produced by this process are somewhat better than castings produce by the traditional process but not as detailed as castings recovered from moulds made from sand and resin. Freezing the mould subsequent to forming structurally strengthens the mould so that it better retains its shape when the molten metal is poured. In addition the greensand can be recycled.

The aim of at least preferred embodiments of the present invention is to provide a mould which can produce castings of comparable quality with moulds incorporating resin without the problems associated with the use of resin and with a low risk of a casting cracking as it cools.

According to the present invention there is provided a method of forming a mould from moist particles of a material comprising sand and from 1 to 15% (by weight) clay, characterised in that said moist particles are

substantially individually cooled to a temperature in the range of -20°C to -110°C and are substantially compressed against one another to form a mould.

Our experiments suggest that the presence of clay is essential since, in its absence, the moulds which were formed had minimal structural strength and would have been totally unsuitable for casting.

Advantageously, said material comprises greensand.

At lower temperatures the cooled particles flow more freely which is particularly advantageous for intricate moulds.

Preferably, said moist particles are cooled to from -30°C to -60°C before being compressed against one another.

Advantageously, the moist particles comprise from 2% to 6% (by weight) water.

The moist particles may be cooled by any convenient means, i.e. by direct or indirect heat exchange with a gas, liquid or solid medium.

Preferably, the moist particles are sprayed and/or tumbled during cooling. This aids heat transfer, as well as reducing the risk of agglomeration. Other forms of agitating the moist particles during cooling may also be used.

The cooled particles can be compacted against a pattern by ramming the material into a box or flask. However, we have found that significantly better results can be obtained by pressing the pattern into the cooled particles to form an impression therein. Typically the pattern should be pressed into the frozen particles with a pressure of from 0.5 bar A to 2 bar B.

Preferably, the method includes the step of insulating said mould after formation thereof. This helps maintain the temperature of the mould prior to pouring.

The present invention also provides a mould made by

a method according to the present invention and an engine component when cast using a mould in accordance with the present invention.

As used herein the term "mould" includes mould cores. The term "particles" includes both individual entities and clusters of entities which will pass through a 1000μm sieve, preferably a 500 μm sieve, and advantageously a 212 μm sieve.

* * *

For a better understanding of the present invention reference will now be made, by way of example to the accompanying drawings in which:-

Fig. 1 shows a step in a method in accordance with the present invention;

Fig. 2 is a graph showing the strength of various moulds as a function of the moisture content and the temperature of the particles prior to formation of the mould;

Fig. 3 is a schematic side elevation of an automated greensand machine;

Fig. 4 is a schematic view of the area encircled and identified by the reference numeral IV in Fig. 2;

Fig. 5 is a schematic view of the area encircled and identified by the reference numeral V in Fig. 3

Example 1

A mixture comprising (by weight) 91% sand, 5% clay (activated bentonite) and 4% water was prepared in the rotating drum of a concrete mixer. While the drum was rotating a jet of liquid nitrogen was sprayed into the drum. This produced a multiplicity of individually cooled grains and small clusters of grains which are referred to herein as "particles".

A pattern 2 was placed on a surface and covered with a box 3 surrounded by insulating material 4.

The cooled particles were passed through a 1000µm sieve and the cooled particles which passed through the sieve were then poured into the box 3 and rammed around the pattern. The box 3 was filled with cooled particles 1 and the top of the particles levelled off as shown. It was observed that the particles flowed very freely a round the pattern. A thermometer was inserted into a pile of particles remaining in the drum of the concrete mixer and a temperature of -20°C was recorded.

The box 3 was removed from the pattern 2 and then

inverted leaving an impression into which molten metal was poured in the usual manner.

It was noted that the mould appeared to be less "active" than conventional greensand moulds, i.e. less gas appeared to be released during pouring. Furthermore, less noise appeared to emanate from the mould.

After the molten metal solidified the casting was removed and the sand and clay recovered for re-use.

The casting was visually examined and found to be very satisfactory, particularly in reproduction of fine detail on the pattern.

It should be noted that the mould was ready for use immediately after compression. This should be compared with one prior art process where the mould is formed and then passes slowly through a tunnel freezer to achieve freezing throughout.

* * *

In the prior art process described hereinbefore the freezing of the moulds was generally a slow and inefficient process, the cold front travelling only very slowly across the mould. In contrast, the cooling of particles as described in the Examples was effected quickly and efficiently.

Example II

A quantity of milled greensand comprising (by weight) 95% sand and 5% clay was dried in a microwave oven. The milled greensand was then divided into three batches and water added so that the batches contained 2%, 4% and 6% (by weight) of water respectively.

Each batch was subdivided into samples and each cooled to a different temperature by heat exchange with liquid nitrogen in a rotary freezer. Typically, the residue time of the particles in the rotary freezer was about 30 seconds.

Each sample was sieved through a 1000 μm sieve to

remove any lumps. 160g was then placed in a 2.54cm internal diameter tube and impacted by dropping a mass of 0.1kg through a height of 10cm three times. The degree of compaction ((initial volume-final volume)/initial volume) was noted and the strength of each sample was measured by removing the compacted sample from the tube and placing it in a machine which slowly increased a compressive force on the sample. The compressive force at which the sample failed was noted.

By way of comparison a similar test was carried out on greensand compressed as above but at ambient temperature. The result of the tests are shown in Fig. 2.

It will be noted that the strength of the mould formed from particles frozen to between -30°C and -80°C was greater than the strength of the moulds formed at room temperature.

The degree of compaction is shown in Table I below. This appeared to depend on whether the water was frozen or not. It will be noted that the moulds formed from frozen particles were less compacted than those which were not formed from frozen particles.

TABLE I

Moisture Content	%Compaction at room temperature	%Compaction of frozen particles
2%	55	51
4%	55	49
6%	57	46

Example III

The procedure of Example I was repeated except that the mixture was cooled to about -40°C. In addition the pattern was immersed in liquid nitrogen until the liquid

nitrogen became quiescent and then allowed to warm to various temperatures before being used.

The quality of the impressions with the pattern at room temperature and at various sub-zero temperatures was assessed visually by a casting technologist. Whilst all impressions were generally acceptable the casting technologist reported that the impressions formed when the pattern was pre-cooled to from -20°C to -110°C was very good and from -30°C to -80°C excellent.

* * *

One of the difficulties encountered with the moulds produced in Example I and II was that thin walled parts of the mould could fail prematurely during casting. This was attributed to insufficient compaction of the cooled particles in the mould. However, attempts to increase the compaction by applying vibration and/or additional pressure to the cooled particles from the back of the mould did not appear to have any significant beneficial effect.

The solution to this problem was somewhat unexpected. In particular, instead of pressing the moist particles onto the pattern the moist particles were placed in a box and the pattern pressed into the material. However, bearing this in mind the present invention was applied to an automated greensand machine diagrammatically shown in Figures 3 to 5.

In particular, Figure 3 shows a diagrammatic view of a modified "Disamatic" automated greensand machine. The machine, which is generally identified by reference numeral 10 comprises a feed hopper 11 mounted on a mould forming machine 12. A guide section 13 extends from the mould forming machine 12 to a shake off section (not shown) via a molten metal dispenser 20.

As can be seen from Figure 4, the mould forming machine 12 comprises a first hydraulic ram 14 which

carries a first pattern 15 and an exit gate 16 which carries a second pattern 17 and is pivotally mounted on a drive shaft 18 which is connected to a second hydraulic ram (not shown).

In use, a mixture similar to that used in Example I was first cooled to -100°C in a rotary freezer (not shown) and then placed in the feed hopper 11.

Exit gate 16 was lowered to a near vertical position and first pattern 15 withdrawn to its left most position as shown in Figure 4.

The cooled greensand, which has the general appearance of a dry powder, was then poured from the feed hopper 11 into the chamber 19 between the first pattern 15 and the second pattern 16. When the chamber 19 was full the first hydraulic ram 14 and second hydraulic ram (not shown) were activated to squeeze the first pattern 15 and the second pattern 17 into the frozen greensand and to form impressions in the respective sides thereof.

After the impressions were formed exit gate 16 was raised to the position shown in dotted lines and the mould ejected onto the guide section 13 by advancing hydraulic ram 14.

As can be seen from Figure 5, a void 21 was formed between adjacent moulds. As the void 21 moved beneath molten metal dispenser 20 it was filled with molten metal, for example aluminium or iron. The molten metal cooled as the moulds travelled towards the end of the guide section 13 where they were transferred to the shake out station where the castings were agitated to remove the greensand which was subsequently recycled to the feed hopper 11.

The bond formed between particles of greensand which have been pre-frozen in accordance with the invention appears to be different from that formed when moist greensand is formed <u>in situ</u>. In particular, when moist

greensand is frozen _in situ_ and the mould subsequently warmed the mould has substantially the same strength as a mould formed from compressed moist greensand. However, when a mould is formed in accordance with the present invention is warmed the mould only has the strength of an _uncompressed_ moist greensand mould.

This property makes the chances of the casting tearing very small indeed. Also, very little effort is necessary to separate the greensand from the casting.

The present invention is particularly applicable to the casting of engines and components for engines. It is particularly useful for the casting of engine components where tears are totally unacceptable and where high residual stresses generated by the casting contracting against the mould must be avoided.

* * *

<u>Claims</u>

1. A method of forming a mould from moist particles of a material comprising sand and from 1 to 15% (by weight) clay, characterised in that said moist particles are substantially individually cooled to a temperature in the range of from -20°C to -110°C and are subsequently compressed against one another to form a mould.

2. A method according to Claim 1, characterised in that said material comprises greensand.

3. A method according to Claim 1 or 2, characterised in that said moist particles are cooled to from -30°C to -60°C before being compressed against one another.

4. A method according to any preceding claim, characterised in that said moist particles comprise from 2% to 6% (by weight) water.

5. A method according to any preceding claim, characterised in that said moist particles are sprayed during cooling.

6. A method according to any preceding claim, characterised in that said moist particles are tumbled during cooling.

7. A method according to any preceding claim, characterised in that said cooled particles are compacted against a pattern.

8. A method according to any of Claims 1 to 6, when said pattern is pressed against said cooled particles to form an impression therein.

9. A method according to any preceding claim, characterised in that it includes the step of insulating said mould after formation thereof.

10. A mould when produced by a method according to any of the preceding claims.

11. An engine component when cast using a mould as claimed in Claim 10.

FIG. 1

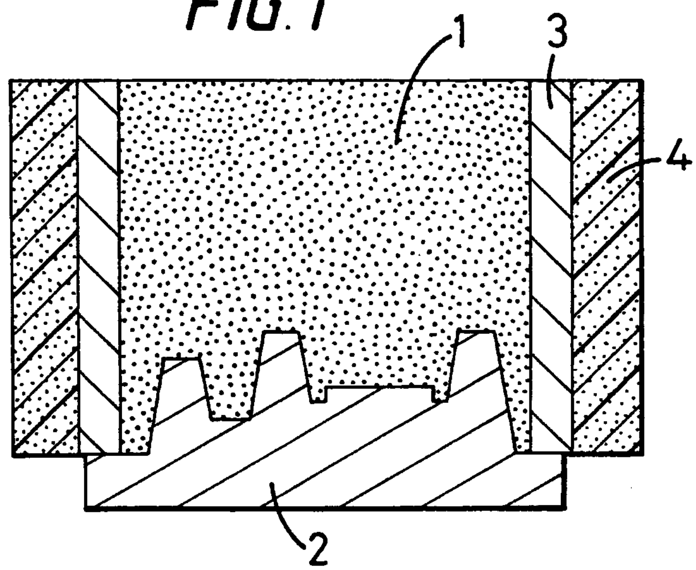


FIG. 2

Variation of Frozen Greensand strength with temperature and moisture content.

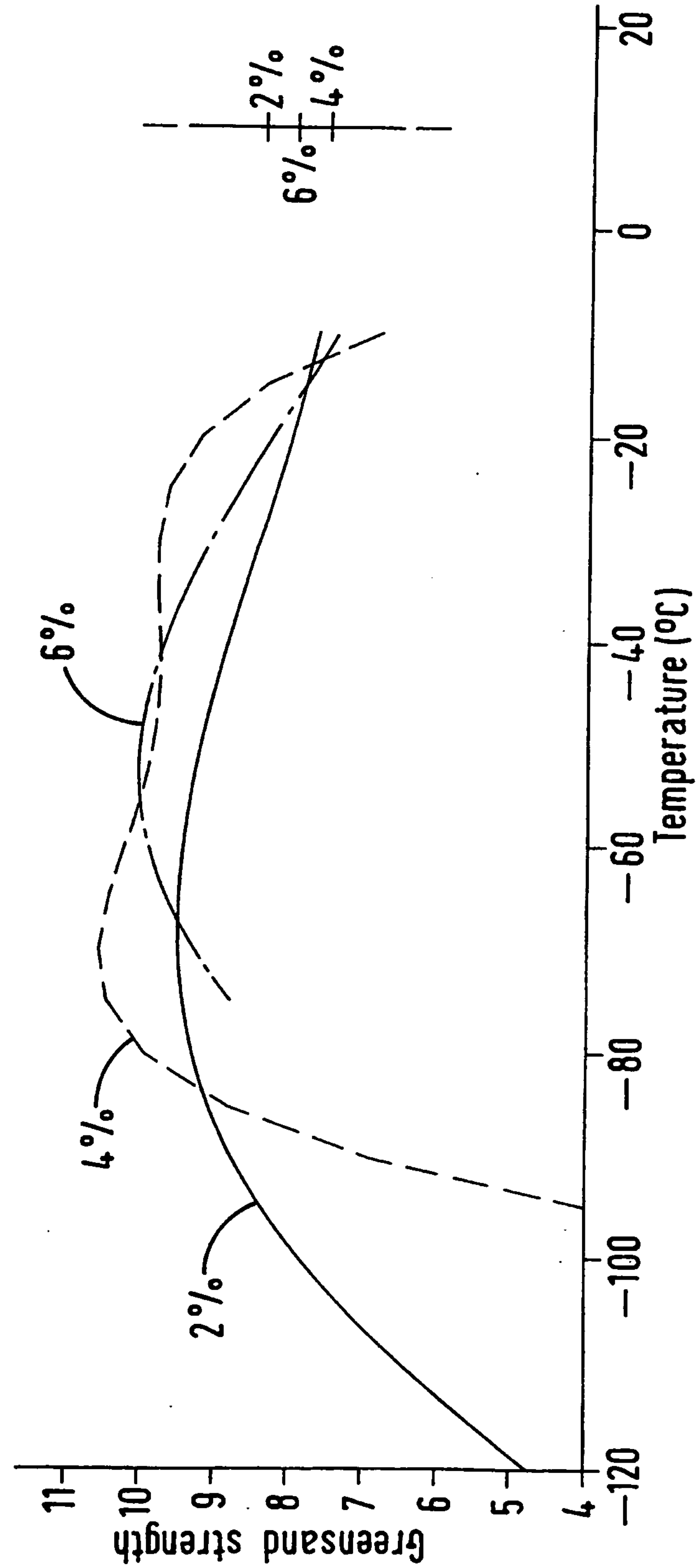


FIG.3

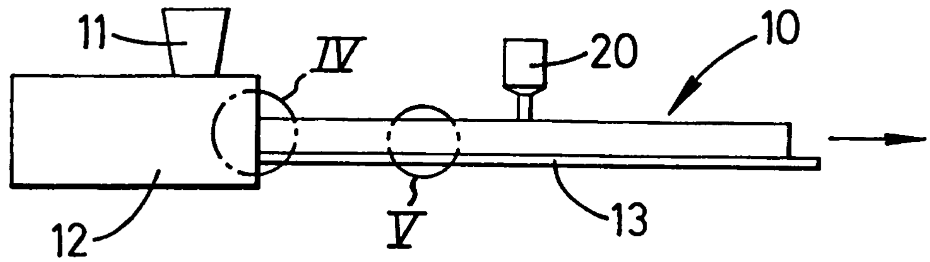


FIG.4

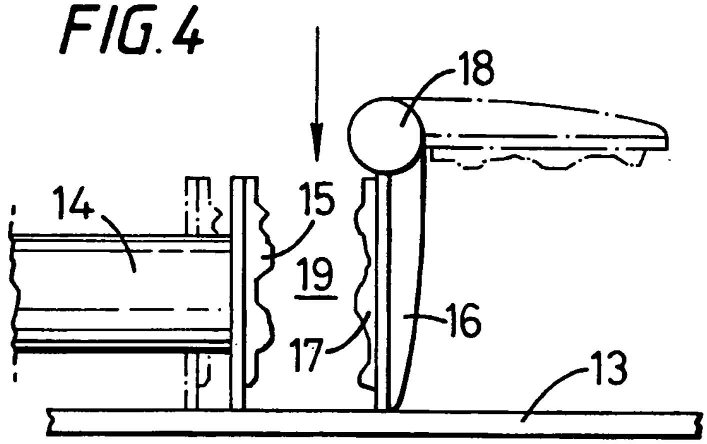
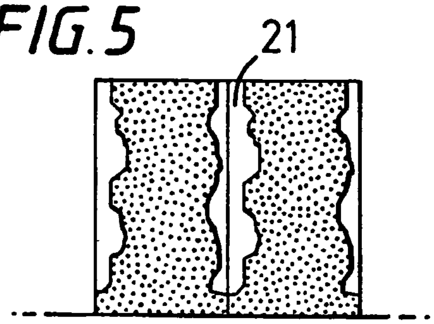


FIG.5



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 96/01467

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B22C9/12 B22C1/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B22C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,4 453 586 (JESPERSEN EMIL ET AL) 12 June 1984 see whole document ---	1-11
X	PATENT ABSTRACTS OF JAPAN vol. 4, no. 125 (M-30) [607] , 3 September 1980 & JP,A,55 084249 (SHINTO KOGYO K.K.), 25 June 1980, see abstract ---	1-11
A	EP,A,0 077 247 (AIR LIQUIDE) 20 April 1983 see claims 1,2 ---	1,3,4
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
9 October 1996	24. 10. 96

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

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PCT/GB 96/01467

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 009, no. 018 (M-353), 25 January 1985 & JP,A,59 166343 (MITSUBISHI JUKOGYO KK;OTHERS: 01), 19 September 1984, see abstract ---	1,5,6
A	PATENT ABSTRACTS OF JAPAN vol. 006, no. 253 (M-178), 11 December 1982 & JP,A,57 149046 (SHINTO KOGYO KK), 14 September 1982, see abstract ---	1
A	PATENT ABSTRACTS OF JAPAN vol. 006, no. 167 (M-153), 31 August 1982 & JP,A,57 081938 (NATL RES INST FOR METALS), 22 May 1982, see abstract -----	1

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INTERNATIONAL SEARCH REPORT

..iformation on patent family members

Intern al Application No
PCT/GB 96/01467

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EP-A-0077247	20-04-83	FR-A- 2514274	15-04-83
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		JP-A- 58074243	04-05-83